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BACTERIAL STALK ROT OF CORN

By H. R. ROSEN

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SUMMARY

The bacterial stalk rot of corn has been reported from Arkansas, New York, North Carolina, Mississippi, Louisiana, Ohio, Illinois, North Dakota, and Arizona.

The disease has been noted in Arkansas for six years and is considered to be serious during those periods of the corn-growing season when the temperature, rainfall and humidity are above normal. In the absence of high temperatures and humidity, the disease is found to be entirely absent or of minor importance.

It is described as primarily affecting the stalks and leaves. Symptoms are as follows: (1) a light- or dark-brown rotting of bases of leaves, particularly those at the base of the stalks; (2) a rotting of the lower portion of the stalk, the affected part being dark-brown, soft, putrid, and sunken in fresh infections. These may extend through the entire width; or, as more frequently found, remain localized as dark, rotted spots with margins appearing water-soaked. The disease consists of a localized necrosis of parenchymatous tissue.

Attacked tissue is found teeming with bacteria and more than 50 isolations are reported from such infections. Many successful artificial infections are also reported, including infections obtained in Hottes chambers in which accurate control of soil and air temperatures are obtainable. It is found that temperature plays an important role in disease inception and development. Below 20° C. no infections take place; between 20 and 25° C. infections are few; between 30 and 35° C. the greatest number of infections are obtained. High humidity is also found essential for infection. A correlation is noted between rapid, succulent growth and disease susceptibility.

Infections are found to take place through hydathodes, stomata, through injuries resulting from the extrusion of endogenous roots, and from insects.

The pathogene is described as a short, plump, rapidly growing rod, white in most culture media, and is considered to be closely related to *Bacillus coli*. Numerous cultural and physiological reactions are described. The pathogene is named *Phytomonas dissolvens* (comb. nov.).

BACTERIAL STALK ROT OF CORN[1]

By H. R. ROSEN
Associate Plant Pathologist

In 1919 *(14)* the Arkansas Experiment Station called attention to a disease of corn prevalent in Arkansas, about which there was very little, if any, information either as to its cause or as to its control. This was followed by two short papers in which brief descriptions of the disease and the pathogene concerned with it were presented. In this bulletin the aim is to present a rather full account of the disease and the disease producer, and little attention will be given to the data which have formerly been presented.

DISTRIBUTION AND EXTENT OF DAMAGE

Subsequent to publication of Arkansas Experiment Station Bulletin 162 *(14)* the disease has been reported by other investigators from the following states: New York, North Carolina, Mississippi, Louisiana, Ohio, Illinois[2], North Dakota, and Arizona[3]. It is of course possible that in some instances this disease may have been confused with some other malady, but it is quite probable that the disease is present in other states as well as in most of those mentioned. As far as Arkansas is concerned, and probably other Southern states, the pathology of corn in general is hardly fathomed as yet.

As to the presence of this disease in other countries, there are no published records available here, with the exception of that by Dawson *(6)* of East Africa, which would clearly indicate this. Even Dawson's report is so brief, that there is some question as to its being the same as that here discussed.

Evidence will be presented which clearly indicates that this is a disease which does damage only during moist, muggy, warm weather, and that regions in which the air temperatures are much below 27° C. during the growth of the corn are apt to be free from it. The disease is almost certain to be present in all the states along the Mississippi River from Illinois southward.

This disease has been noted by the writer in Arkansas every year since 1919 (6 years). Field observations have been made and specimens received from a wide area over the state, including the Mississippi River (eastern) section, as well as

[1]The data presented in Phytopathology 16: 241-267, 1926, is the same as that prsented in this bulletin. Additional notes on the motility of the organism are here presented. Thanks are due to the ediors of Phyopathology for the use of the half-tones.

[2]U. S. Department of Agriculture. Bureau of Plant Industry, and Plant Disease Survey. Corn Diseases. In U. S. Dept. Agr. Bur. Plant Indus. Plant Disease Bul. Supplement 21, pp. 232, 233. 1922. (Mimeographed.)

[3]Ibidia. Supplement 27, pp. 238-239. 1923. (Mimeographed.)

the Ozark (western) section. During the years when summer rainfall is quite low, the disease does very little damage and cannot be responsible for a loss greater than one to two per cent of the corn. But when the late June, July or August precipitation is more than usual, as occurred in some sections of the state in 1920 and in 1925, the disease is by far the most serious one in the state. Losses amounting from 10 to 30 per cent of the stalks in different fields have already been recorded *(15)*. In 1924 the disease was noted in epidemic form at Fayetteville in a small garden of sweet corn—11 out of 20 hills of Golden Bantam having the disease and other varieties to a lesser extent. During 1925 quite a few reports and specimens were received from a number of counties in the eastern part of the state, including Randolph, Independence, and Jackson. Some of the correspondents who reported considerable damage and who also sent specimens for identification, wrote as follows: "I am sending you specimens of corn stalks that have become affected with what appears to be stalk rot. This corn appeared to be in a healthy condition until a few days ago. Now many stalks are falling over and are being attacked to a more or less extent." (Extract from letter of E. Y. Fitch, June 29, 1925.) "This is the only field I know of that is damaged, but there is considerable damage in it." (Extract from letter of J. E. Critz, June 27, 1925.) "I am sending you herewith specimens of stalks of corn that have us somewhat puzzled as to what is the cause of the rotting off just at the top of the ground. This condition is quite prevalent in this county (Independence), especially in rich delta or bottom lands—and in some instances is materially affecting the stands. This corn has not suffered seriously from moisture, nor has the temperature exceeded about 98 to 100 degrees F., and at this time there is plenty of moisture, but not excessively wet." (Extract from letter of S. C. Knight, June 27, 1925.)

As to the damage done by this disease in other states, Edgerton's report[1] is of interest. "The bacterial stem rot of corn described by Rosen from Arkansas has been known in Louisiana since 1908. I saw it the first year that I was in Louisiana and have seen it to some extent nearly every year since. Some years it is very troublesome in some localities and other years it is of little importance." This corresponds closely to the writer's observations in Arkansas. From Illinois, Tehon (*20*, p. 197) reports the following on the disease,—"It was found in Illinois in 1921 in two counties, Jackson and Randolph, where it was reported as serious in the fields affected by it. In 1922 it was again found in small amounts in a single field in Union County, where it was reported to be causing the death

[1]U. S. Department of Agriculture. Bureau of Plant Industry. Corn Diseases. In U. S. Dept. Agr. Bur. Plant Indus. Plant Disease Bul. Supplement 21, pp. 232-233. 1922. (Mimeographed.)

of one per cent of the stalks. In 1923 it was seen in Alexander County, where an examination of 100 acres revealed two infected stalks." Roy C. Thomas in a letter dated September 29, 1924, reports the following from Ohio. "So far, I have noticed the disease upon two varieties only, namely the Golden Bantam and Country Gentleman. I have not given much attention to the matter except as specimens have been sent to us from time to time, because it does not appear to be of sufficient importance in Ohio to be considered of economic importance. We notice it for three or four weeks and then it will be difficult to find diseased plants."

As already indicated the disease is to be looked for primarily in the southern portion of the corn growing section, although it appears that it may develop to some extent farther north (probably during exceptionally moist, warm periods). In addition to the varieties previously mentioned *(15)* as susceptible to the disease, the following sweet corn varieties have been found susceptible: Golden Bantam, Stowell's Evergreen, and Country Gentleman.

DESCRIPTION OF THE DISEASE

The symptoms have already been discussed in former publications *(14, 15)*. Additional information permits some cor-

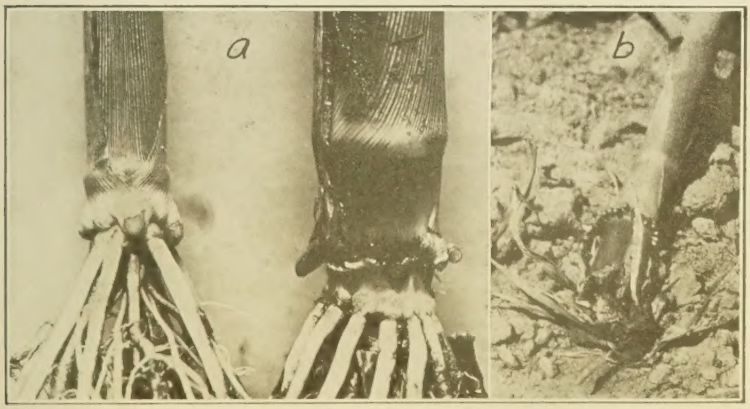

Fig. 1. a—Plant on right artificially infected at a lower node, the resulting rot involving several adventitious roots as well as stalk tissue. Plant on left served as check.

b—Natural infection at a lower node which included root infection.

rections and additions. The disease is primarily one affecting the stalks and leaves. The name "root-rot," first applied *(14)*, is misleading. It was used because the first observations showed the roots as the main seat of disturbance, but further study

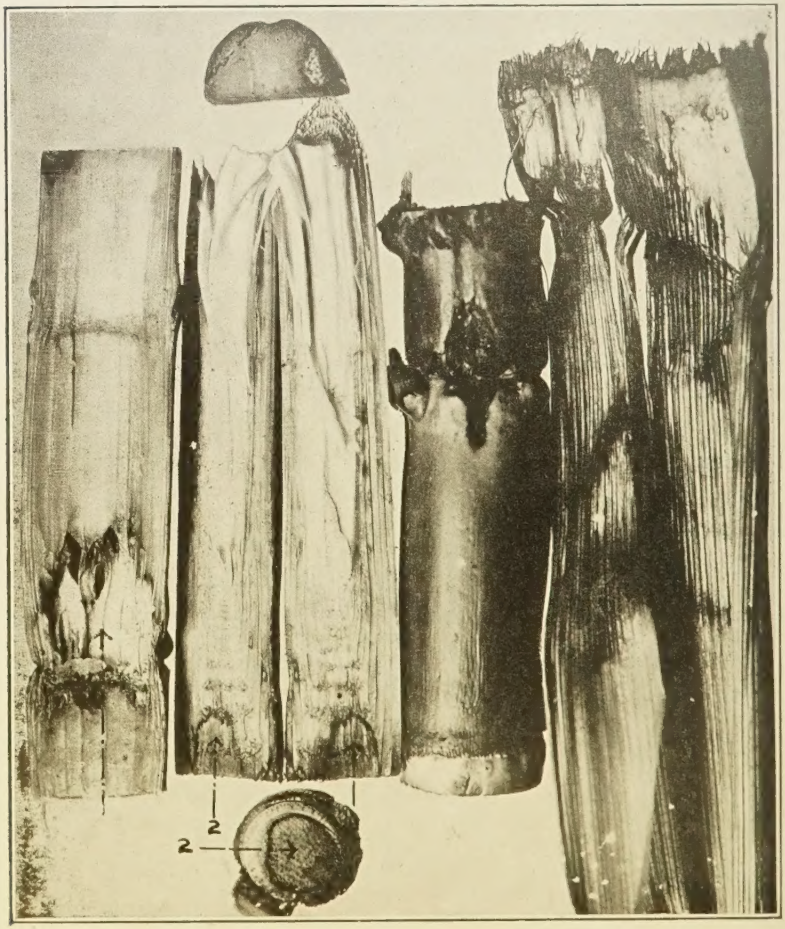

Fig. 2—Natural infections; arrow at extreme left pointing to internal pocket of dry rot or later stage, other arrows (2) pointing to an early, wet rot stage; sheath at the extreme right showing discoloration and disruption of tissue occurring at an infected node.

has shown that this was due to some other cause which happened to accompany the bacterial disease in the field where it was first observed. The compact, matted appearance of the roots, as first described, has not been observed in any subsequent material, and this was probably largely due to wire-worm injury, the matting of the roots representing successive efforts on the part of the host to replace the elongated roots cut short by the wire-worms. Also, too much emphasis was placed on the purplish-brown discolorations of the interior of lower nodes, this feature being more or less common to a number of root troubles (and perhaps in the absence of parasitic root troubles), and is only significant in this disease when accompanied by a characteristic rotting of the same or adjoining tissue (Fig. 1).

Briefly, the symptoms are: (1) A light-brown or dark-brown rotting, and premature dying of the leaves, mostly the lowermost (upper leaves rarely become infected), usually beginning in the parts joining the stem and confining its attack primarily to parts of the sheath (Fig. 2); (2) a yellowing and withering of the leaf blades whose sheaths have become rotted; (3) a rotting of the stalk, usually at a lower node (Fig. 3), often at the node immediately above the soil line; the rotted part in severe infections is a dark-brown or blackish, soft, putrid, sunken mass, often with a grayish-white slime, in recent infections, and becoming light-brown, shriveled and broken up in older infections. (Pl. 1.) In most cases the infection does not extend through the whole thickness of the stalk, confining itself either to a small localized blackish spot with the margin appearing water-soaked, not extending more than 0.25 inches into the interior and invading only a small part of the nodal circumference (Fig. 4), or the infection beginning at some external point on the node extends into the interior, invading a considerable part of this without showing much at the surface; or lastly, the rot may involve the whole circumference of the node and extend but a short way into the interior. As formerly reported *(15)*, the complete rotting of a lower node and the subsequent falling over of the stalk are symptoms of this disease in severe infections (Fig. 3). Roots which happen to be attached to those parts of the stalk which are diseased will likewise become infected, but it should be noted that this disease is primarily a stalk and leaf rot and not a root rot; likewise that leaf blades in contrast to leaf sheaths are rarely infected, though they have often been infected artificially (Fig. 5).

It is often difficult to distinguish this disease on the leaf sheaths from leaf spotting due to other causes, particularly those spots which are associated with the presence of pollen sacks and aphis honey dew in the ventral side of the sheath, and which according to Durrell *(8 and 9)* make it possible for fungi and bacteria which ordinarily lead a saprophytic existence to

penetrate the sheath and produce discolored spots. However, such spotting is mostly found on the leaf sheaths, while the bacterial disease here described is conspicuous as a stalk infection, and while the bacterial disease is found on young as well as on older plants (Fig. 3), Durrell notes that at least the Diplodia dry rot fungus (one frequently involved in sheath rots) is found mostly on older plants.

What is the explanation for the prevalence of this disease on lower parts of the plant? In other bacterial diseases which are not systemic and which are not particularly associated with insect dissemination, primary infections are also apt to appear on parts close to the soil line. Black rot of cabbage, black leg of potato, angular leaf spot of cotton, immediately come to mind as good illustrations of this. The same thing is true for a large number of fungus diseases. Closeness or contiguity to soil is the main explanation, the pathogene either being associated with the seed or more directly with the soil. In the latter instance the pathogene lives over on formerly diseased material of past crops or lives a more or less independent existence in the soil (a rather rare occurrence). In these instan-

Fig. 3—Typical stalk rot close to the soil involving an extreme disintegration of localized stem tissue.

a—Rot of older plant.

b—Rot of young plants; plants prostrate as a result of extreme rotting. Photographed at Burdette, Ark., June 27, 1921.

ces dissemination is largely by driving and spattering rains or by surface drainage. The angular leaf spot of cotton is a very good illustration of this. In addition to closeness of soil, the frequency of injuries around the crown of the plant, either in the form of natural wounds (to be discussed later), or in the form of insect and other injuries, also play an important role in rendering the lower parts of the plant more subject to disease.

ISOLATION AND ARTIFICIAL INFECTION EXPERIMENTS

It has previously been reported that the pathogene is rather easily isolated *(15)*. During the six years that have elapsed since its discovery, it has been isolated more than fifty times from natural and from artificial infections. Owing to the great abundance of bacteria in infected portions, a mere bit of material from any portion of the rotted tissue is usually sufficient for microscopic examination. With but the pressure of a cover glass the bacteria ooze out of such tissue, floating in a drop of water, in very observable grayish-white clouds, which under the microscope are seen as enormous numbers of very small, short rods, often in pairs. Not infrequently other microorganisms, including various fungi and comparatively large-sized or motile bacteria, are also to be seen in rotted tissue, but if care is taken to choose only freshly infected tissue, then these small plump rods are quite frequently the only microorganisms to be observed. Within the parenchymatous tissue of the corn stalk, which it will be recalled occupies a considerable part of the stalk, the bacterial pathogene thrives and multiplies rapidly (under suitable conditions of moisture and temperature), infected cells being filled with bacteria. The pathogene has never been observed in the vascular tissues, and as the rotted region is always more or less limited in extent the disease may be considered as a localized one. It may be possible to have localized infections of vascular systems, but the common observance of this disease in the form of shredded fibers at rotted joints, representing the vascular systems, which at times appear variously twisted by action of the wind, is external evidence of the lack of vascular infection (Pl. 1, a). Conceivably, should any injury occur to the xylem of the amphivasal corn bundle, so that the phloem would be exposed, then this might become infected.

Isolations by means of platings from internal tissues, either without subjecting this interior tissue to a germicide, or submitting this tissue to the action of mercuric chloride for the customary minute or two and then washing in sterile water, is very apt to result in good isolation (Pl. 2). By that is meant a series of plates in which but one type of colony appears. In order to be certain that any fungus, which might be present and

which might be lost by bacteriological dilution culture methods, is isolated, bits of tissue were surface sterilized and washed, and plated out directly without macerating on various media, especially potato glucose agar and nutrient agar. This, in conjunction with the dilution plate method, should enable one to isolate fungi as well as bacteria which may be present. As a result of a large number of such trials it was possible to establish early in the work the presence of a certain bacterium in the diseased tissue. Of the fungi which have been encountered in such rotted areas, *Rhizopus* spp. and *Fusarium* spp. lead in frequency. But inasmuch as the tissue harboring these fungi was always teeming with bacteria, while many isolations revealed no fungi, there is no good reason for considering these other than as secondary invaders. Occasionally other species of bacteria have been isolated from diseased material, but having once learned to distinguish the pathogene, other bacterial colonies which appeared sporadically were readily explainable as secondary invaders or as contaminations.

Artificial infections have been attempted on somewhat more than 2000 plants, involving about 150 separate trials in the field and greenhouse, and typical symptoms have been obtained from a considerable number of these, approximately 20 per cent. It was discovered early in the work that infections were not always obtainable, and these failures at times could not be ascribed to any lack of virulence on the part of the organism, as success and failure occasionally occurred in different trials conducted but a few days apart. As failures became at times more common, and typical infections discouragingly rare, it seemed necessary to make a thorough study of environmental factors as related to disease inception and development. Furthermore, the sporadic outbreaks of the disease under field conditions, which were noted at times as regular epidemics in some localities, followed by a more or less complete subsidence of the disease, made it all the more desirable to undertake such a study.

Dr. Charles F. Hottes, of the University of Illinois, very kindly permitted the use of the excellent control apparatus which he had devised. This consists of a series of large glass chambers in which temperature and humidity, and light to some extent, can be accurately controlled. Time permitted only a study of the effect of temperature on infection. Three different series were run in these chambers at different times, and the results check up closely in the three. As far as humidity is concerned, it had previously been ascertained that little or no infection was obtainable in a dry atmosphere during the incubation period, and that to insure infection a very moist or rather a practically saturated atmosphere was necessary. This was obtained by wetting large strips of filter paper and placing this on the inside of large bell jars next to the walls. All plants,

checks as well as those inoculated with bacteria, were treated the same way. Inoculations were made by spraying the plants with fresh cultures of the bacteria growing upon nutrient agar slants. The spraying apparatus consisted of sterilized, all-metallic artist's syringes. Wounded as well as unwounded plants were treated, the wounds consisting of needle pricks and knife incisions on stems, usually at the base.

Summarizing the results of these experiments, it was found that below 20° C. there were no infections; between 20 and 25° C. infections were few and much limited in the size of tissue affected and in the severity of infections; between 25 and 30° C., infections were more numerous, the size of infections greater and the discolorations and disintegrations of the affected cells much more severe; between 30 and 35° the greatest number of infections were obtained, the affected area showing the greatest amount of disintegration and death of tissues.

A portion of the notes of one of these series reads as follows: December 1, 1922, 11:00 A. M.—sprayed one pot of corn (Neil's Paymaster) with Burdette strain, another pot with Jackson County (Illinois) strain, and one with sterile water. Three such pots placed in each chamber at the following temperatures: 15° C., 20° C., 25° C., 30° C., and 35° C. Bell jars lined internally with wet filter paper placed over each pot.

December 2, 9:00 A. M.—35° Chamber reads 36°. Others O. K.

December 3, 8:30 A. M—35° Chamber reads 40°. Others O. K. Bell jars removed. In 30° chamber, yellow tips noted on several leaf blades of pots of both strains, one leaf showing withered area around margin.

December 4, 8:30 A. M.—Plants in 35° chamber showing brownish-yellow tips in pots of both strains, no leaf discoloration of plants sprayed with sterile water. Same observations on the plants in the 30° chamber. In the 25° chamber, two leaves with yellow tips in the pot sprayed with Burdette strain, none with Jackson County strain. No discolorations at 20° or at 15° C. At 25° one tip of a true leaf and one coleoptile tip of another plant infected, infection being in the form of yellowish-brown discoloration extending one continuously downward and involving the whole width of the leaf and coleoptile, with an indefinite lighter colored border. Microscopic examination shows brownish tissue teeming with bacteria, which ooze out in thread-like whorls in a water mount.

At 30°, pot sprayed with Jackson County strain showing one leaf with dark brown withered tip and with light yellow border extending about one half way down the leaf and farther, extending as a broad, yellow streak along the midrib. Pot sprayed with Burdette strain showing five leaves of as many plants infected. Symptoms comparable to those given above.

Each leaf carefully examined under the microscope and found to harbor bacteria in the discolored and dead areas.

At 35°, pot sprayed with Jackson County strain shows four true leaves on as many plants badly diseased at the tips and extending along the sides for several centimeters or involving most of the leaf area. Same symptoms as at 30 . Each infected leaf examined under the microscope and bacteria found in each. All coleoptiles brown, and more or less disintegrated near the soil line. Pot sprayed with Burdette strain shows six leaves badly infected at the tips and sides. Four others with infections just beginning at the tips. No fungi were noted in the whole of the above recorded plants and the bacteria appeared as the typical short, plump rods. All check plants sprayed with water remained healthy.

December 5, 8:30 A. M.—Temperature of 35° chamber reads 33°. Others O. K. No infections noted other than those recorded above.

December 6, 8:30 A. M.—Pot kept at 35° and sprayed with Burdette strain shows one seedling with dead stem, the brown water-soaked tissue extending from below the soil line to above the node, 1.5 to 2 cm. in length. Microscopic examination shows tissues teeming with bacteria; no other microorganisms found. All other plants showing no stem rot.

December 7, 8:30 A. M.—Pot at 30° sprayed with Burdette strain shows three seedlings with brown discoloration at the base of the stem, the discoloration extending into the interior. Microscopic examination shows plenty of bacteria in the tissues; no other microorganisms observed. Pot at 30 sprayed with Jackson County strain shows one plant, previously wounded at the base with a knife, with brown discoloration and rotted tissue at base of stem. Microscopic examination reveals bacteria present. Wounded, uninoculated plants appear perfectly sound, with no noticeable discoloration.

These studies clearly show that temperature plays a very important role in the inception and development of the disease. Attention is called to the fact that both air and soil temperatures were under control in these experiments. They fully confirmed field observations and the numerous other trials at artificial infection made in the field and in the greenhouse, in which it was found that no infections occurred unless the temperature was fairly high.

This naturally leads to the question as to direct effect of temperature on the growth and health of disease-free corn and on the pathogene itself. A number of investigators have studied the effect of temperature on corn, particularly on seed germination and on seedling development. The careful work of Lehenbauer *(10)* and of Dickson *(7)* is especially worthy of note. The former made an intensive study of the effect of

temperature on the growth of corn seedlings, using Dr. Hottes' control apparatus. He finds that the optimum temperature for the growth of shoots of maize seedlings in water culture for a twelve hour period is 32° C. (89.6° F.). At high temperatures,

Fig. 4—Arrows at extreme left point to rotted areas, internal view, followed by external view (to the right). No. 3 represents a nodal lesion which has not progressed to any extent into the interior. Extreme right hand figure shows spots on sheath.

31° and above, the growth of these shoots is not maintained, there being a marked falling off in this rate during prolonged periods of exposure. He also finds that there is no such thing as an optimum temperature for corn seedlings, but rather a time-temperature relationship, and states that "the optimum temperature for growth under these conditions is found to change as the length of the period of exposure is altered." The growth rate at medium temperatures accords with the van't Hoff law, showing a doubling of the rate for each rise of 9° or 10° C. Dickson finds that corn seed germination takes place more rapidly at 32° C., seedlings develop most vigorously and most uniformly at the soil temperatures of 24° to 28° C. Corn

matures faster at comparatively high temperatures, the floral parts developing first at about 28° to 32° C., while at soil temperatures below 16° he was not able to bring corn to maturity. In general he finds that corn functions best at rather high soil temperatures. While there does not appear to be a close agreement between the work of Lehenbauer and Dickson, this is at least in part to be explained by the differences in treatments, and in standards of measurement, one using both soil and air temperatures and the other using primarily soil temperatures. For the present, in the absence of further work, it may be assumed that, other factors being favorable for good growth of corn, comparatively high soil and air temperatures are best suited to its vegetative vigor and perhaps productiveness.

In order to determine the relationship of temperature to the growth of the pathogene, several tubes of nutrient agar slants were inoculated with fresh cultures of two different strains (cited above) and placed, in duplicate, in the 20°, 25°, 30°, and 35° chambers used at the same time for one of the artificial infection series. At the end of 18 hours there was good growth at 35° and at 30°, a noticeable decrease in size of smear at 25°, and a very marked decrease at 20° C. As will be shown more fully later, this is a very rapid growing organism under suitable conditions.

It appears then that temperatures that are best suited for the growth of corn are also best for the growth and infectivity of the pathogene. Field evidence supports these greenhouse and temperature chamber studies. In all the more or less serious outbreaks of the disease it has been found that the weather was very warm and moist during the attacks; and conversely, in the absence of such weather very little of the disease has been noted. Associated with this, the lower latitudes found in the eastern part of the state, particularly along the Mississippi River, in contrast to the western or hilly section showed more frequent outbreaks and the disease showed more of its worst forms, i. e. complete rotting of a localized portion and a subsequent falling over of the stalk.

While temperature undoubtedly plays a very important role in the development of this disease, humidity, as already indicated, apparently plays just as important a role. While no experiments have been conducted with adequate controls, to substantiate this statement, all the observations on artificial and natural infections tend to show it to be true. United States government records of precipitation and humidity of Mississippi County, Arkansas, for August, 1920, are of interest. (This was the locality and date in which 10 to 30 per cent of the corn was found ruined.) Only six clear days are reported for the whole month, while five days are listed as partly cloudy, twenty days cloudy, and five days with precipitation. Although the total

rainfall was only 4.5 inches, being 1.54 inches more than normal, the large number of cloudy days is perhaps of greater significance. Numerous comparable records could be cited which clearly show that a high humidity is indispensable. For example, the very best artificial infections, i. e. those closely resembling natural stalk infections of the severe form, have been obtained in the field only when rainy weather set in immediately after the plants were inoculated. This was particularly noticeable during the last days of June and the first few days of July, 1925. (See Fig. 2.) On the other hand, with a few exceptions under greenhouse conditions in which corn does

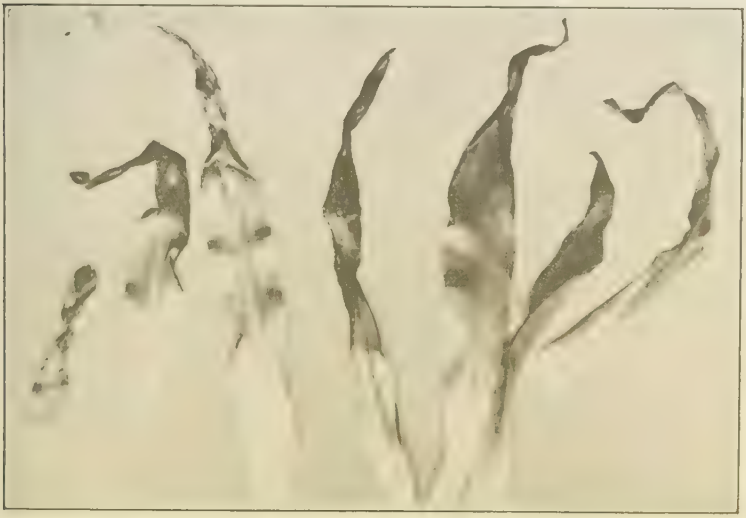

Fig. 5—Artificial infections on leaf blades in form of dark- or light-brown, withered tips, inoculum in the form of a young culture suspended in water, applied as a fine spray by means of a sterilized, all-metallic artist's syringe. Check plants sprayed with sterile water, otherwise treated in same way as inoculated plants, had healthy leaves.

not make the vigorous growth obtainable under proper field conditions, while infections were obtainable the extreme forms of stalk rot have not been obtained. The explanation for this appears to be something more than the necessity of moisture for bacterial invasion, for plants covered with bell jars for 48 hours or more have been kept with moist leaf surfaces and with little or no extreme stalk rot developing. Occas-

ionally these have been obtained [see (14), Fig. 3]. It appears likely that conditions which make for succulence of the host, in which a comparatively large amount of soft, parenchymatous tissue and a small amount of hard woody tissue is being formed, are the direct factors which predispose a plant to infection and extreme necrotic developments. In this respect the well-known fire blight of pears may be cited as a disease comparable to the bacterial stalk rot of corn.

PATHS OF INVASION

In artificial infection experiments with seedlings, infections often appear on the leaf blades in which the inoculum is applied as a spray. This is to be expected, as very little actual stalk surface is exposed. Very often these infections start at the apex, indicating entrance of the pathogene through the apical hydathode (Fig. 5). Microscopic examination of such infections invariably reveals the pathogene in great numbers within the infected tissue. In addition to this form of invasion, isolated spots and streaks of blades and sheaths indicate other forms, i. e. by means of stomata or wounds. Invasion by means of leaf stomata is apparently rare, though at times obtainable. In contrast to this, when environmental conditions were proper, excellent infections were obtained through stomata situated at the lower portion of the stalk (Pl. 3, b). In this region the stomata are much more common than may be supposed. Careful studies of natural infections seem to indicate that this is one of the most common ways in which the bacteria gain entrance in the stalk. In order to test this out, a number of stalks growing in the field were inoculated by means of needle smears around the crowns, care being taken not to wound the plants; these smears were then covered with moistened absorbent cotton. Other stalks were treated in like manner, with the exception that needle pricks were made and the organism smeared in and around these. The number of infections obtained by smears was fully as great as that obtained by pricks. In these experiments, also, it is worth noting that in periods of dry weather infections by either method were few.

As far as wounds are concerned, attention has previously been called (15) to the natural wounds common to the corn stalk at the lower nodes, when endogenous roots are pushed out. Artificial infections have been obtained in these regions (Fig. 1), and examinations of natural infections have shown a number of cases where infections appeared to have started in tissue ruptured by the passage of one or more roots. Early infections of this sort appear as light-brown water-soaked areas of the leaf sheath and of the adjoining stalk tissue surrounding the root. Injuries caused by various insects also have been found to offer excellent paths for infection.

A histological study of diseased tissue reveals discolored cells which, depending upon the age and progress of infection, show various stages of disintegration. In young infections there is little disintegration present, the bacteria being found within the cells and in the surrounding intracellular spaces. In older infections, however, many of the parenchymatous cells are more or less completely broken up and disjointed, and only remnants of tissue may be observed with cells appearing more or less intact. The extreme rotting and loss of cell cohesion make the disease comparable to the soft rot of vegetables due to *Bacillus carotovorus* Jones or to the Rhizopus rot of various fruits and vegetables; a study of the enzyme action of this pathogene in all probability would reveal enzymes that are capable of acting upon pectic compounds.

THE PATHOGENE

Morphology. The organism is a short, plump, rapidly growing rod (see Pl. 3, c). (As the organism is a marked acid and gas producer and has other characteristics of *Bacillus coli* it seemed desirable to compare these in various ways and the results of such comparisons will be presented.) At temperatures of 25-30° C. growth appears within twelve hours on suitable media, while at twenty-four hours profuse, heaped up, growth usually appears on agar slants or on plates. With the exception of one glaring error the brief description previously given *(16)* for this pathogene characterizes it quite well. The statement that it is motile by means of a single polar flagellum is only partly correct. Some strains are non motile while others are distinctly motile and typical infections have been produced with both kinds. (Since the publication of this data in Phytopathology infections have been obtained with a motile, monotrichic strain.)

As previously recorded the average measurements of preparations stained by ordinary methods are 0.7-1.2 × 0.5-0.9μ. The organism is frequently found in groups or clumps, doubtless due to the slimy envelopes, often in pairs and rarely in chains. Capsules are present (see Pl. 3, d), as may readily be observed by using the Plimmer and Paine method *(13)*. By this method, including the enveloping capsules the average measurements are 1.5-1.8 × 1.0-1.3μ. No spores have ever been observed. Many young and old cultures have been variously stained, with no indications of spores. As the pathogene takes the form of rather small sized rods, spores would perhaps not be expected. It is Gram negative, using the method described by Burke *(4)*. *Staphylococcus aureus* with the same stain gives a positive test. Counter-stained with safranin, the corn organism stains red, while *Staphylococcus* remains deep blue. It is not acid fast. A broth culture, 24 hours old, stained with Ziehl's carbol fuchsin

and then treated with 20 per cent sulphuric acid for a moment shows no color. When counter-stained with aqueous methylene blue the organism appears blue with no trace of red.

CULTURAL CHARACTERS

Agar Plates.—On peptone-beef agar poured plates kept at 25° C., many of the colonies become visible in 24 hours, and in 48 hours most if not all are visible. They are white, round, smooth, glistening, opaque, have a consistency of melted butter or of boiled starch; the elevation is convex, edge entire, and the structure amorphous. Deeply imbedded colonies, next to the glass, are flat, spreading and have a tendency to form concentric rings. When held up to a bright light the colonies appear brilliantly fluorescent. After three weeks, when the medium is well dried out, colonies show a marked tendency to form a flat, spreading growth, zonated near the margin, the margin noticeably lobed and scalloped.

Agar Stroke.—At 25° C. there is a good growth in 24 hours, reaching a width of 4 to 5 mm., at the base of the slant, and tapering upward. The growth is filiform to spreading (Pl. 2, b), raised or convex, glistening, smooth, butyrous, and opaque. (One strain isolated from Burdette, Arkansas, showed a brownish color developed in most of the common media.) Odor is marked in many strains and less evident in others, resembling putrid decaying matter.

Agar Stab.—Growth occurs along the entire length of the stab, somewhat better above, gas bubbles produced along the line of puncture (see Pl. 2, c) and at times extending out through entire thickness of the medium. As a result the medium becomes variously cracked. Growth finally occurs in the pockets made by the gas bubbles. By suspending pieces of filter papers soaked with Nessler's reagent over cultures and heating, a brownish color develops on the paper, indicating that these gas bubbles were probably ammonia.

Gelatin Plates.—Growth at 17-20° C. is rather slow and not copious; colonies are round, white, with entire margins. There is no liquefaction.

Gelatin Stabs.—At 15-20° C. growth is observable down the whole length of the stab at the end of three days. There is no liquefaction at the end of five weeks. The line of growth is filiform and there is a tendency for gas formation (ammonia) observable as bubbles near the line of growth.

Nutrient Broth.—In peptone-beef broth testing P_H 7, kept at 25° C., there is a noticeable clouding and a slight precipitate, but no pellicle at the end of 24 hours. In 48 hours there is a greater surface growth mainly observable in the form of a ring

and floccules, or compact slimy masses and streamers. Fine whitish granules are formed in most strains (absent in some), clouding gives place to a marked turbidity with numerous floccules; the sediment is abundant and rather cohesive in most strains. In many strains there is a marked putrid odor. In contrast to the corn organism, *Bacillus coli* forms a much heavier surface growth, the sediment is never viscid (at least in the strain here used) and breaks up into compact flaky particles.

Nutrient Broth Over Chloroform. As compared to growth on the same medium in free air, there is no clouding in 24 hours, though the precipitate is about the same. In 48 hours there is no surface growth, and the granules are not nearly as abundant as in free air; the sediment is just as heavy but is more compact. At the end of six days, growth still appears considerably restricted.

Nutrient Broth Plus Alcohol. Upon adding absolute alcohol to nutrient broth, so as to make 2, 3, 4, 5, 6, 7, 8, 9, and 10 per cent solutions, growth occurs in 2, 3, 4, and 5 per cent, with a heavy surface pellicle, something which does not occur in ordinary broth. At the end of three weeks, when considerable alcohol has evaporated, surface growth occurs in all up to 10 per cent, indicating that, while the alcohol at higher percentages may have considerably retarded growth and perhaps killed some of the organisms, it did not kill all the organisms at the concentrations used.

Sodium Chloride in Nutrient Broth. At the end of three days, growth appears to be equally good up to 3 per cent. At 4 and 5 per cent there is very little growth.

Loeffler's Blood Serum. Growth is restricted and whitish. There is no liquefaction.

Lima Bean Agar Slants.—Growth in 24 hours is very heavy, superior to that on nutrient agar in the same time interval, the greater growth being even more noticeable at the end of 48 hours. On this medium growth is more spreading, less opaque, and there is a greater tendency for gas production. The medium was made up according to the directions given in a previous publication (*17*, p. 369).

Uschinsky's Solution. Growth is good, fluid is not rendered viscid.

Fermi's Solution.—No growth at the end of five days.

Potato Cylinders.—At 25° C. there is good growth in 24 hours. It is quite heavy, heaped up, creamy-white, glistening, and not slimy. Growth is best on the moist part of the medium at the base of the cylinder. *B. coli* shows a similar type of growth but is somewhat darker in color, grayish white and flatter, with

a greater tendency to spread. After the corn organism had grown on the cylinders for about a month, the cylinders were macerated, 10 cc. of distilled water added, and 1 cc. of an alcoholic solution of iodine. A purplish red (very near dusky auricula purple of Ridgway) immediately developed, indicating a partial starch hydrolysis. Cylinders upon which *B. coli* had been grown for the same length of time, treated the same way, developed a deep blue color, comparable to the color of uninoculated and similarly treated cylinders.

Nutrient Broth Plus 1 Per Cent Potato Starch.- Growth is very heavy at the surface, in the form of an adhering pellicle. At the end of 11 days it was tested for starch hydrolysis by the same method given for potato cylinders. A purplish blue color appeared immediately which gradually changed to a reddish blue, finally losing all color by standing over night. Similar treatment of growths of *B. coli* remained deep blue. This test and the one on potato cylinders indicate that the corn organism possesses diastatic action.

Potato Dextrose Agar Slants.—At 25 growth is copious, raised, shining, and white. In some strains there is a marked viscidity, the growth pulling away from the medium in fine thread-like fashion, when touched with a loop. No such sliminess was noted in *B. coli*. In 48 hours there is a noticeable production of gas in the corn organism and much more in that of *B. coli*.

Milk.—At the end of three days at 25° C. milk begins to clear in the form of a watery, honey-yellow band appearing at the surface. Coagulation is delayed, but becomes quite marked by the sixth day; color of medium is not changed. At the end of the same period cultures of *B. coli* extrude whey which remains white and not clear, as in the corn organism. On the eighteenth day, upon the addition of methyl red, cultures of the corn organism show but very faint pink, while *B. coli* cultures show a pink of around P_H 5.2.

Litmus Milk.—There is no change in color up to the third day, aside from the watery, honey-yellow surface band, but by the sixth day the lavender color has changed to a pinkish-cream, indicating acid production. Testing with brom cresol purple, with colorimetric comparisons, the active acidity is about P_H 5.4.

Indol Production.—On the tenth day, using the Ehrlich test, nutrient broth gave a positive test for indol. Tests by the sodium nitrite-sulphuric acid method were negative. It is of interest to note that in broth containing sodium chloride there is a decreasing amount of pink in the Ehrlich test as the percentage of salt is increased, being very markedly pink in 1 per

cent and only faintly so in 5 per cent. This would seem to indicate that moderately strong solutions of table salt, and probably other salts, either hinder the production of indol or prevent its detection.

Development of Crystals.—In old cultures of nutrient broth containing 1 per cent dextrose, there is a noticeable development of crystals. These appear similar to those figures by Smith [*19*] Fig. 57, No. 21. Tests for tyrosin with Mellon's reagent were negative; likewise tests for tryptophane with bromine vapor gave negative results.

Nitrite Production.—Growth is fairly abundant within 48 hours in nitrate broth. Some strains develop a compact, viscid sediment. Surface growth is only noticeable as a faint ring. Tests for nitrites with starch water-potassium iodide on the tenth day are positive. (Checks gave no tests.)

Hydrogen-Ion Concentration in Relation to Growth.—Nutrient broth was rendered acid and alkaline by adding hydrochloric acid and sodium hydroxide aseptically after the broth had been sterilized. The following series (4 tubes of each) was used: P_H 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 7.5, 8.0, 8.5, and 9.0. Growth occurred in the whole series, beginning with P_H 5.0. Below that, at the greater hydrogen-ion concentration, there was no growth. It appears that the organism has a rather wide range with reference to hydrogen-ion concentration, and is especially tolerant of alkaline conditions.

Toleration of Acids.—The following acids were added aseptically to nutrient broth after it had been sterilized; acetic, citric, hydrochloric, lactic, oxalic, and phosphoric. The concentration used for each was 0.1 per cent. The resulting hydrogen-ion concentration was: acetic acid P_H 4.9, citric P_H 5.0, hydrochloric P_H 4.8, lactic P_H 4.7, oxalic P_H 4.7, phosphoric P_H 4.5. Growth occurred only in the citric acid broth, testing P_H 5.0. It would take more work to show whether this means that the corn organism is intolerant of anions other than citrates, or whether the lesser concentration of hydrogen-ions in the citric acid broth was responsible for the growth.

Hydrogen Sulphide Production.—Filter paper saturated with lead acetate hung over cultures in nutrient broth, and in nutrient broth plus 1 per cent potato starch, failed to show any color, indicating no hydrogen sulphide production. However, this test is not satisfactory. The recent one recommended by the committee on pure culture studies, American Bacteriological Society (Manual of Methods), has not been tried.

Ammonia Production.—Cultures several days old, in peptonized beef broth testing P_H 7, respond readily to a test for ammonia (filter paper saturated with Nessler's reagent). The

odor of ammonia is not detected, however, possibly because of the very marked putrid odor produced by some strains of this organism.

Gas Production.—In the presence of carbohydrates this organism is a marked gas producer. (It has already been shown that in the absence of carbohydrates, this organism also produces gas, but this gas, ammonia, is the product of protein decomposition.) Gas production has been carefully studied in fermentation tubes and the results presented in the following table.

GAS PRODUCTION IN FERMENTATION TUBES

Carbohydrate	Relative amount of gas in closed arm in 24 hours	Amount of gas in per cent after 5 days	Proportion of H to CO_2
Dextrose	Abundant	60 (25)*	1:1, (2:1)*
Galactose	Noticeable	15	1:1
Mannite	Noticeable	60	1:1, (2:1)*
Sucrose	Noticeable	60 (50)*	1:1
Maltose	Abundant	50 (30)*	1:1, (2:1)*
Lactose	Noticeable	25	1:1
Raffinose	Noticeable	25 (25)*	1:1
Inulin	Absent	Little in 5 days; 25 in 10 days	
Glycerin	Noticeable	20 (30)*	

*Figures in parentheses refer to *B. coli* cultures which were run at the same time.

Acid Production.—Lactose agar stabs containing Andrade-Penny's indicator kept at 25° C., develop a pinkish color in 18 hours, with considerable gas production in the form of bubbles. The pink color denoting acid development remains after two months of growth. In order to ascertain the active acidity developed by the corn organism in the presence of different carbohydrates, 1 per cent of each of the carbohydrates listed below was added to the nutrient broth. The acidity was determined by colorimetric comparisons, using the Clark and Lubs indicators.

ACID PRODUCTION IN PRESENCE OF CARBOHYDRATES

Type of Carbohydrate	Original P_H	P_H at end of 11 days
Dextrose	6.8	6.0
Galactose	6.8	6.0
Mannite	6.8	6.0
Sucrose	6.8	5.4
Maltose	6.8	5.4
Lactose	6.8	6.1
Raffinose	7.1	6.1
Potato starch	6.8	5.4
Check (nutrient broth)	7.0	7.0

From the foregoing table it will be seen that considerable acid is produced in two disaccharides and in one polysaccharide; otherwise the acid production is not very great. Unfortunately in the series just presented no comparisons were made with *B. coli*. However, in a series of agar slants containing litmus as an indicator, and in the presence of various carbohydrates, the original blue was changed to red in six hours by *B. coli*, while the corn organism cultures remained blue, or showed only a mere trace of red or pink. These consisted of the following: Galactose, mannite, sucrose, lactose, raffinose, and glycerin. In 24 hours, however, all the carbohydrates showed a whole reddening of the media in the corn organism as well as in *B. coli*. It thus appears that the latter organism develops a greater acidity in a short interval of time than the corn organism.

Germicidal Action of Mercuric Chloride.—A comparatively equal amount of the organism, growing in bouillon, was transferred to 10 cc. of mercuric chloride of the following dilutions: 1:1000; 1:10,000; 1:50,000; 1:100,000; and 1:500,000. At the end of five minutes a drop of each dilution was transferred to a tube of nutrient broth. No growth occurred in the following: 1:1000; 1:10,000; 1:50,000; while the transfers from 1:100,000 and 1:500,000 showed growth in 24 hours. After fifteen minutes exposure, transfers from 1:100,000 failed to grow, while those from 1:500,000 appeared unaffected. It appears then that mercuric chloride is a very efficient germicide for this organism.

PHYSIOLOGICAL REACTIONS

Effect of Temperature on Growth.—In connection with the artificial infection experiments, attention has already been called to the fact that this organism grows best at around 30 to

35° C. In addition to the study there reported, the organism grown on nutrient broth was subjected to various temperatures below 20° C., resulting in very poor growth or no growth at all. At 15° there is a slight clouding in five days; at 10° there is a very faint cloud at the end of eight days; while at 0° C. there appears to be no growth. Due to lack of facilities the upper limits of growth have not been determined. Based on records of other bacterial pathogenes, this would probably be about 40° C., with the death point several degrees above that. In reality such studies as these here reported, and in common use, are of little significance as to the effect of temperature under natural conditions, because under these conditions constant temperatures are almost never obtained. It would be far better to subject the organism to field temperatures obtainable at different times of the year.

Effect of Drying.—Diseased material collected during July of 1921 was kept in a dry condition in the laboratory until the late summer and then placed near an open recess in a building where it was sheltered from rain but more or less subject to outdoor temperatures. Here it remained until the first week in July, 1922. A portion was then thoroughly washed, macerated in sterile water, and the suspension was then sprayed on one pot of corn seedlings, resulting in typical infections, particularly in three seedlings that had been wounded (uninoculated but wounded plants remained healthy). The infected portion of one of the plants was then washed, surface sterilized, macerated in sterile water and then plated out. In the series of ten plates, pure cultures were obtained without a single evident contamination. Transfers from the pure culture isolations were in turn inoculated on another group of plants, resulting in two typical infections on as many plants. From one of these the pathogene was reisolated. It thus appears that the organism may readily live over for a year at least in dry tissue.

Overwintering.—The foregoing data also indicate one method by which the pathogene may live over winter. As the primary seat of stalk infection is close to the crown of the plant, the diseased part has an excellent opportunity of remaining undisturbed during harvesting of the corn, whether or not the stalks are cut. The stubble remaining on the field serves as a source of infection for next year's corn if no rotation is practiced. Experimental evidence for other means of overwintering unfortunately is not at hand, due to the destruction of inoculated ears on three different occasions. Field data gathered at various places seem to indicate that the pathogene may also be carried in or on seed. For example, one field after clearing of timber was used for growing corn for two years, then alfalfa for seven years, followed by another crop of corn. Upon this last

crop the disease was discovered. Of course such evidence is not very satisfactory for various reasons. For one thing, ears are yet to be found showing natural infections. Although ears showing rotted husks and kernels have been frequently observed, some of which harbored bacteria in the diseased parts, all attempts at isolation have yielded either fungi or bacteria which have no resemblance to the species here discussed. Hence the actual means of disease introduction in different localities remain to be investigated. As artificial infections are obtainable on leaf blades and sheaths, and as natural infections on lower sheaths are common, there is very good reason to suspect that natural infections take place on husks at least, and also perhaps on the kernels themselves. Indeed, in one case a bacterial stalk rot was obtained on a Golden Bantam seedling growing in sterilized soil. The seed came from the same lot as those which produced 11 diseased hills out of 20, previously mentioned.

Effect of Low Temperatures and of Freezing. Three different experiments were undertaken to determine the effect of very low temperatures. First: freshly made strokes on nutrient agar, as well as full grown strokes, were put into a calcium chloride water mixture, operated in conjunction with an ice machine, with a temperature of —17° C. Tubes were left in this for 10, 30, 60, 90, and 120 minutes, and then placed in a 30° incubator. After 24 hours of incubation, growth occurred on all the freshly made strokes, while transfers made from the full grown ones also made successful growth. Second: old strokes of two different strains growing on nutrient agar were placed into a melting ice mixture, kept there for two hours, and then placed in a 30° incubator. All transfers made from these grew. Third: a loopful of a 48 hour broth culture was placed in each of four tubes containing the same quantity of nutrient broth. Three of the tubes were placed in a freezing brine ice mixture, the broth solidifying and kept in this frozen solid stage for two hours. After thawing, poured plates were made from similar quantities of each of the three tubes, as well as from the check. Counts of the number of colonies developed from check as well as from the frozen cultures showed a reduction of about 90 per cent of the colonies in the frozen cultures. Considering the differences in media and in type of treatment, these three experiments are not as conflicting as they appear. While the mortality of the organism in a liquid medium subject to extreme freezing is high, it can as a whole withstand very low temperatures.

Effect of Sunlight.—Poured plates placed on a block of ice in bright sunlight (mid-day of the 22nd of June), with one half of each plate covered with black paper, were exposed for

varying periods of time. Those exposed for 30 and 45 minutes showed no difference in number of colonies between exposed and unexposed halves. But those subjected to one hour exposure and over were almost entirely killed. Compared to other bacterial phytopathogenes, some of which are said to succumb at exposures of 15 to 30 minutes, the corn organism is not as sensitive to sunlight.

Vitality on Culture Media.—On ordinary media such as nutrient broth, nutrient agar, and on milk, the organism lives for quite a few months. For example, nutrient agar stroke cultures kept in an icebox for ten months, during which time the medium dried out very much, although not losing all moisture, when transferred to nutrient agar showed growth in 24 hours.

Group Number.—Using the most recent chart (1925) issued by the Society of American Bacteriologists *(5)*, the index number is 5000 (or 5020)-32021-1111.

Relationship of This Disease to Burrill's Bacterial Disease of Corn.– In the first publication *(1½)* of this disease it was stated that it "has been known since 1889" and that it was first described by Burrill. This statement was based upon Dr. Burrill's description of the disease *(2 and 3)* and not upon any specimens seen. Having now made a very complete study of all the specimens left by Burrill at the University of Illinois, it is possible to report that it is very doubtful if the disease or diseases he dealt with is the one here considered. Most, if not all, the material examined showed various blade and sheath spots (see Pl. 1, e), quite comparable to the spots described by Durrell *(8 and 9)*. Only one cornstalk specimen was found, representing a seedling, and in this the symptoms are markedly different from the bacterial stalk rot. Microscopic examination of a number of these spots shows various fungi and bacteria present within the tissues, confirming the gross symptoms as to type of disease. All the collections examined, including those having the following numbers, show the ordinary sheath spots: 9153, 10527, 25896, and 32392.

Aside from the question as to whether the disease described by Burrill is the one here discussed, Burrill described but apparently did not name the causal organism, though various well-known authors, including Russell (*18*, p. 36), Migula (*12*, p. 315), Ludwig (*11*, p. 95), Voglino (*21*, p. 37), and quite a few of the more recent authors of text-books attribute both *Bacillus Zeae* and *Bacillus secales*, the latter supposedly a synonym, to Burrill. Most of these writers cite Burrill's publications on this subject, and when these are carefully studied it appears very doubtful if the authors ever read Burrill's work. He has only two articles on the corn disease that are of importance *(2 and 3)* and several others that are merely abstracts

and reviews. In none of these does he give any name. The earliest use of the name *Bacillus Zeae* Burrill that has been found appears in Russell's work *(18)* in 1892, and it would not be surprising if that author, who was working on practically every bacterial pathogene then known and on others, for convenience adopted a name and used for authority the name of the man from whom he had obtained his cultures. Certainly, as late as 1891 Burrill had not given a name to the organism, for on package No. 10527 of Burrill's material, the following data is found: "A Bacterial Disease of Corn, *described by Burrill but not named*" (writer's italics). "On Zea mays, Urbana, Ill. June 17, 1891. G. P. C(linton) Det. McCluer, Coll." This date is so close to the date of Russell's publication, 1892, that the explanation offered above for the origin of the name (or rather two names) seems plausible.

The difference between the disease here discussed and Stewart's disease has previously been presented *(14)*.

TECHNICAL DESCRIPTION

Phytomonas dissolvens (comb. nov.).*
(Pseudomonas dissolvens Rosen.)

Motile or non-motile, short, plump rods, average measurement of single rods 0.6 by 1.0μ, facultative anaerobe, acid and gas produced on various carbohydrate media; no spores; capsules present; colonies on nutrient agar plates white, round, entire, glistening, opaque, some strains emitting a strong putrid odor; nitrates reduced to nitrites; ammonia produced; indol produced; hydrogen sulphide not produced (?); diastatic action marked; fair growth in Fermi's and Uschinsky's solutions; good temperature for growth 30 ; vitality on culture media comparatively long; gelatin not liquefied; somewhat sensitive to drying, freezing, and sunlight; Gram negative; not acid fast. Pathogenic on *Zea Mays* L.

See p. 2 for summary.

*If one considers the aim of classification to consist primarily of bringing together and grouping into genera all forms that are morphologically related, then the recent proposals brought out by the Society of American Bacteriologists *(1)* will be condemned; but if the similarity of physiological processes, rather than morphology, be considered the guide, then the new proposals will be accepted. So little is actually known about the morphology as well as physiology of the supposedly well known organisms, that almost any system which would be proposed is certain to be full of errors. The important thing for the present is agreement among bacteriologists on one system; otherwise, chaos in nomenclature is sure to rule. The recently proposed genus Phytomonas is therefore accepted. If Migula's classification is followed the combination should be *Pseudomonas* or *Bacterium dissolvens* (comb. nov.); and if Erwin F. Smith's classification is used the combination *Bacterium* or *Aplanobacter dissolvens* (comb. nov.) is suitable.

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PLATE 1.

a—Natural infection at a lower node showing extreme necrosis and shrinking of diseased tissues and disjointed threads, representing remnants of the fibro-vascular bundles. Marked depression in nodal circumference due to destruction and collapse of parenchymatous tissue.

b—Artificial infections on Country Gentleman by means of needle pricks, the needle carrying pure cultures of the pathogene; infections appear as small, dark-brown, or blackish streaks and spots.

c—Artificial infection on Mexican June field corn, in the form of a rotted internode, resulting from hypodermic injection of a pure culture of *Phytomonas dissolvens* (checks injected with sterile water remained healthy).

d—Natural infections on lower part of stalk, mostly in the form of localized spots.

e—Typical specimen, representing sheath infections, left by Dr. Burrill in the herbarium of the University of Illinois and labeled by him, "probably bacterial".

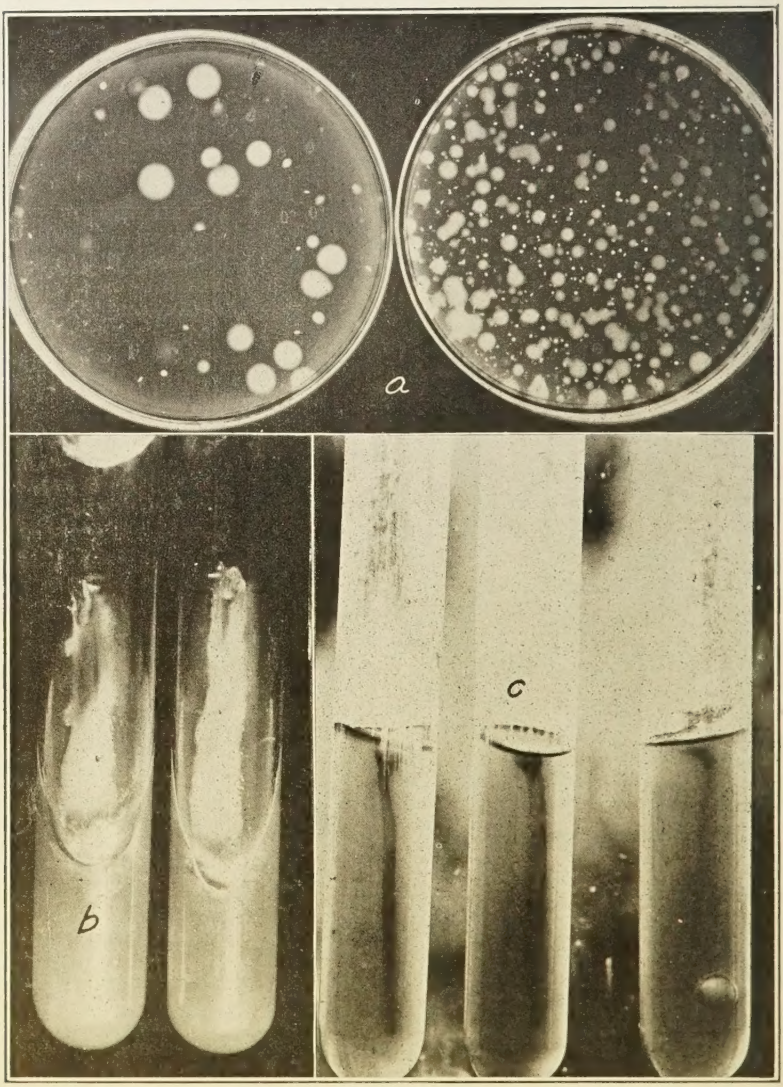

PLATE 2.

a—Colonies of *Ph. tumorus dissolvens* isolated from a rotted node, 48 hours old, on nutrient agar. Surface colonies whitish, opaque, buried colonies are much flatter and appear lighter.

b—Growth on nutrient agar slant after 24 hours at 28° C.

c—Growth of the corn pathogene along entire length of stab in nutrient agar, with a gas bubble shown in one.

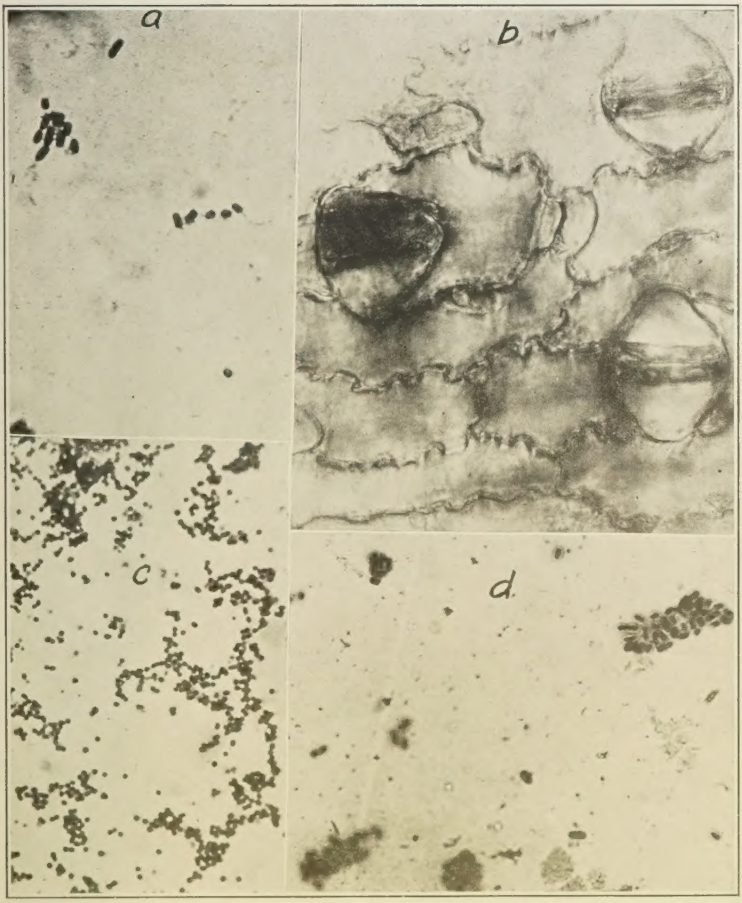

PLATE 3.

a—*P. dissolvens* stained by the Van Ermengem method for showing flagella. The streamer, connected to the rod on the extreme right, appears to be a flagellum.

b—Artificial inoculation of *P. dissolvens* on Golden Bantam sweet corn, showing relationship of stomata to infection. View represents an unstained water mount of a tangential section of the cornstalk immediately below the soil line. Note the bacteria, appearing as a dark mass, in a cell adjoining one of the stomata, the two other stomata and their neighboring cells being normal.

c—*P. dissolvens* stained with carbol-fuchsin. Magnified about 1,000 times.

d—Corn pathogene stained to show capsules. This staining enlarges the organism considerably as compared to ordinary staining. Magnified about 1,000 times.